IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

POLAROID CORPORATION, Plaintiff and Counterclaim Defendant, v. HEWLETT-PACKARD COMPANY, Defendant and Counterclaim Plaintiff.	C.A. No. 06-738-SLR REDACTED

**DECLARATION OF WILLIAM J. MARSDEN, JR.
IN SUPPORT OF DEFENDANT HEWLETT-PACKARD'S
OPENING SUMMARY JUDGMENT BRIEF ON ESTOPPEL AND LACHES**

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Dated: May 16, 2008

I, William J. Marsden, Jr., declare as follows:

1. I am an attorney with Fish & Richardson P.C., counsel for Hewlett-Packard Company. I am a member of the Bar of the State of Delaware and of this Court. I have personal knowledge of the matters stated in this declaration and would testify truthfully to them if called upon to do so.

2. Attached hereto as Exhibit 1 is a true and correct copy of excerpts of the expert report of Dr. Allyn Strickland. REDACTED

3. Attached hereto as Exhibit 2 is a true and correct copy of excerpts of the expert report of Robert H. Wallace. REDACTED

4. Attached hereto as Exhibit 3 is a true and correct copy of excerpts of the deposition of Bradford Kullberg, dated December 6, 2007. REDACTED

5. Attached hereto as Exhibit 4 is a true and correct copy of excerpts of the deposition of Bradford Kullberg, dated Jan. 25, 2008. REDACTED

6. Attached hereto as Exhibit 5 is a true and correct copy of Polaroid's Admissions No. 6 and No. 1. REDACTED

7. Attached hereto as Exhibit 6 is a true and correct copy of United States Patent No. 4,829,381.

8. Attached hereto as Exhibit 7 is a true and correct copy of Polaroid's Interrogatory Responses Nos. 2, 15 and 18. REDACTED

9. Attached hereto as Exhibit 8 is a true and correct copy of excerpts of the deposition of Nathan Moroney. REDACTED

10. Attached hereto as Exhibit 9 is a true and correct copy of the "Moroney 11/00 Task List" (HPPOL_0052837) . REDACTED

11. Attached hereto as Exhibit 10 is a true and correct copy of the "Moroney Article" (POL_000616-10).

12. Attached hereto as Exhibit 11 is a true and correct copy of the "Moroney Presentation" (HPPOL_0052679-98). REDACTED

13. Attached hereto as Exhibit 12 is a true and correct copy of excerpts from the deposition of Jay Thornton. REDACTED

14. Attached hereto as Exhibit 13 is a true and correct copy of the "Polaroid 1/06 IP Monetization Project" (CRA 007452) . REDACTED

15. Attached hereto as Exhibit 14 is a true and correct copy of excerpts of the deposition of Bradford Kullberg, dated December 5, 2007. REDACTED

16. Attached hereto as Exhibit 15 is a true and correct copy of the "Thornton 1/02 Status Report" (POL 000702). REDACTED

17. Attached hereto as Exhibit 16 is a true and correct copy of excerpts of the deposition of Ranjit Bhaskar. REDACTED

18. Attached hereto as Exhibit 17 is a true and correct copy of the "Malibu Image Enhancement Timeline" (HPPOL_0381772). REDACTED

19. Attached hereto as Exhibit 18 is a true and correct copy of the "Moroney 9/01 Task List" (HPPOL_1720523). REDACTED

20. Attached hereto as Exhibit 19 is a true and correct copy of the "Moroney 11/01 Images" (HPPOL_0137707-08). REDACTED

21. Attached hereto as Exhibit 20 is a true and correct copy of excerpts of the expert report of Dr. Robert L. Stevenson. REDACTED

22. Attached hereto as Exhibit 21 is a true and correct copy of excerpts of the expert report of Dr. Peggy Agouris regarding infringement. REDACTED

23. Attached hereto as Exhibit 22 is a true and correct copy of the "Sawyer 10/01 Email" (HPPOL_1759263R-70). REDACTED

24. Attached hereto as Exhibit 23 is a true and correct copy of excepts of the deposition of Ronald T. Reiling. REDACTED

25. Attached hereto as Exhibit 24 is a true and correct copy of the "Kimball 3/02 Email" (HP_68880). REDACTED

26. Attached hereto as Exhibit 25 is a true and correct copy of excerpts of the deposition of Jim Lyons. REDACTED

27. Attached hereto as Exhibit 26 is a true and correct copy of the HP 6/02 News Release, "HP Invests More than $1 Billion to Reset Printing and Imaging Market."

28. Attached hereto as Exhibit 27 is a true and correct copy of the HP 8/02 News Release, "Digital Imaging 'Takes the Cake' at Star-Wars-themed Wedding."

29. Attached hereto as Exhibit 28 is a true and correct copy of the Deskjet 3600 Series User's Guide (HP_20428).

30. Attached hereto as Exhibit 29 is a true and correct copy of the Deskjet 5650 User's Guide (HP_20088).

31. Attached hereto as Exhibit 30 is a true and correct copy of the Deskjet 5850 User's Guide (HP_20428).

32. Attached hereto as Exhibit 31 is a true and correct copy

REDACTED

33. Attached hereto as Exhibit 32 is a true and correct copy

REDACTED

34. Attached hereto as Exhibit 33 is a true and correct copy of the "Reiling 3/03 Letter" (HPPOL_11713783-84). REDACTED

35. Attached hereto as Exhibit 34 is a true and correct copy

REDACTED

36. Attached hereto as Exhibit 35 is a true and correct copy of the "HP 8/03 Big Bang 2 Launch Presentation" (HPPOL_0133816-42).

37. Attached hereto as Exhibit 36 is a true and correct copy of excerpts of the deposition of Royal J. Spragg. REDACTED

38. Attached hereto as Exhibit 37 is a true and correct copy of the CNN 8/03 Article, "Is HP the New Apple?" (POL 7244910-11).

39. Attached hereto as Exhibit 38 is a true and correct copy of excerpts of the deposition of Anand Srinivasan. REDACTED

40. Attached hereto as Exhibit 39 is a true and correct copy of excerpts of the deposition of Paul Fredrickson. REDACTED

41. Attached hereto as Exhibit 40 is a true and correct copy

REDACTED

42. Attached hereto as Exhibit 41 is a true and correct copy of excerpts of the deposition of Steven W. Greer. REDACTED

43. Attached hereto as Exhibit 42 is a true and correct copy of excerpts of the deposition of Charles Moore. REDACTED

44. Attached hereto as Exhibit 43 is a true and correct copy of Polaroid's Interrogatory Responses Nos. 22 and 23. REDACTED

45. Attached hereto as Exhibit 44 is a true and correct copy of excerpts the deposition of Julian Bullitt. REDACTED

46. Attached hereto as Exhibit 45 is a true and correct copy of the "Polaroid Project Memo" (CRA 5407). REDACTED

47. Attached hereto as Exhibit 46 is a true and correct copy of excerpts of the deposition of Dr. Dan Schonfeld. REDACTED

48. Attached hereto as Exhibit 47 is a true and correct copy of excerpts of the deposition of Thomas Berge. REDACTED

49. Attached hereto as Exhibit 48 is a true and correct copy of Polaroid's Reply to HP Interrogatory Responses. REDACTED

50. Attached hereto as Exhibit 49 is a true and correct copy of HP's Interrogatory Response No. 15. REDACTED

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed this 16th of May, 2008, at Wilmington, Delaware.

/s/ William J. Marsden, Jr.
William J. Marsden, Jr.

CERTIFICATE OF SERVICE

I hereby certify that on May 16, 2008, I electronically filed with the Clerk of Court the foregoing document using CM/ECF which will send electronic notification of such filing(s) to the following counsel:

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William J. Marsden, Jr.

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Exhibit 1

SEALED DOCUMENT

Exhibit 2

SEALED DOCUMENT

Exhibit 3

SEALED DOCUMENT

Exhibit 4

SEALED DOCUMENT

Exhibit 5

SEALED DOCUMENT

Exhibit 6

United States Patent [19] | [11] Patent Number: 4,829,381
Song et al. | [45] Date of Patent: May 9, 1989

[54] SYSTEM AND METHOD FOR ELECTRONIC IMAGE ENHANCEMENT BY DYNAMIC PIXEL TRANSFORMATION

[75] Inventors: Woo-Jin Song, Waltham; Donald S. Levinstone, Lexington, both of Mass.

[73] Assignee: Polaroid Corporation, Cambridge, Mass.

[21] Appl. No.: 182,987

[22] Filed: Apr. 18, 1988

[51] Int. Cl.⁴ H04N 5/235; H04N 5/208
[52] U.S. Cl. 358/168; 358/166; 358/32; 358/164
[58] Field of Search 358/166, 167, 36, 37, 358/168, 169, 32, 164

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Primary Examiner—James J. Groody
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Attorney, Agent, or Firm—Edward S. Roman

[57] ABSTRACT

A system and method are provided for continuously enhancing electronic image data received in a continuous stream of electronic information signals wherein the electronic information signal corresponding to each pixel of the image recorded is selectively transformed as a function of the average value of electronic information signals for a select plurality of pixel values in the immediate area of the pixel value being transformed. The electronic information signal transformations are provided on a pixel-by-pixel basis to increase contrast in localized areas that may be either exceptionally light or dark as a result of varying scene lighting conditions.

13 Claims, 2 Drawing Sheets

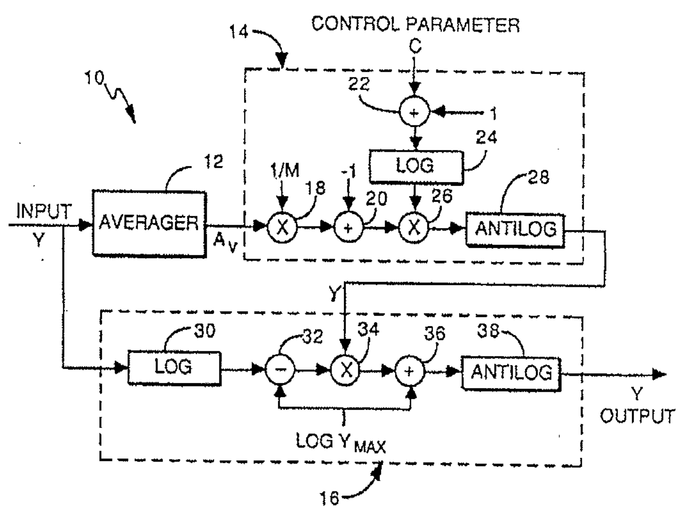


FIG 1

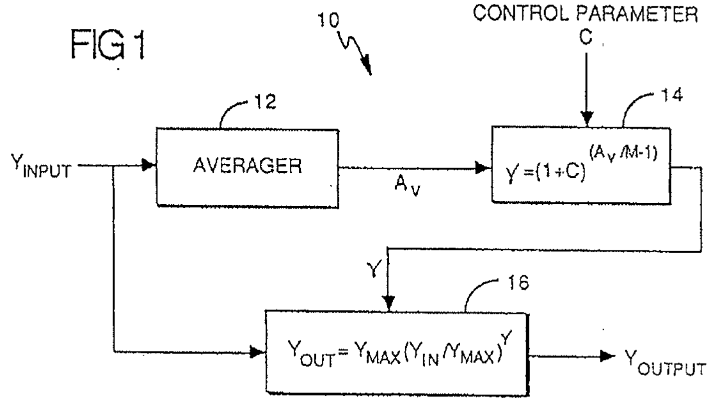
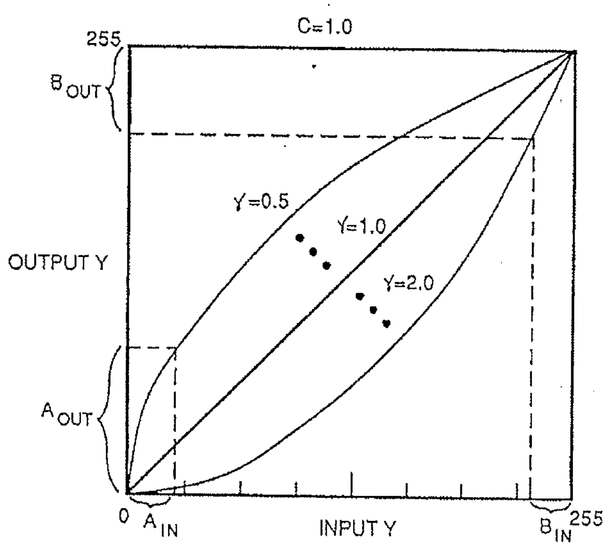

10
CONTROL PARAMETER
C
12
14
Y_{INPUT}
AVERAGER
A_V
$\gamma=(1+C)^{(A_V/M-1)}$
γ
16
$Y_{OUT}=Y_{MAX}(Y_{IN}/Y_{MAX})^{\gamma}$
Y_{OUTPUT}

FIG 2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OUTPUT Y
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B_{IN}
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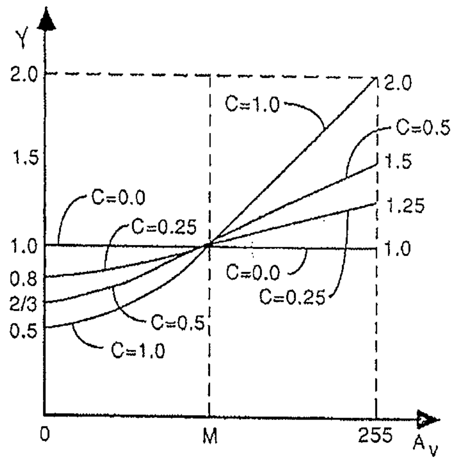

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1.0
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2/3
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C=0.0
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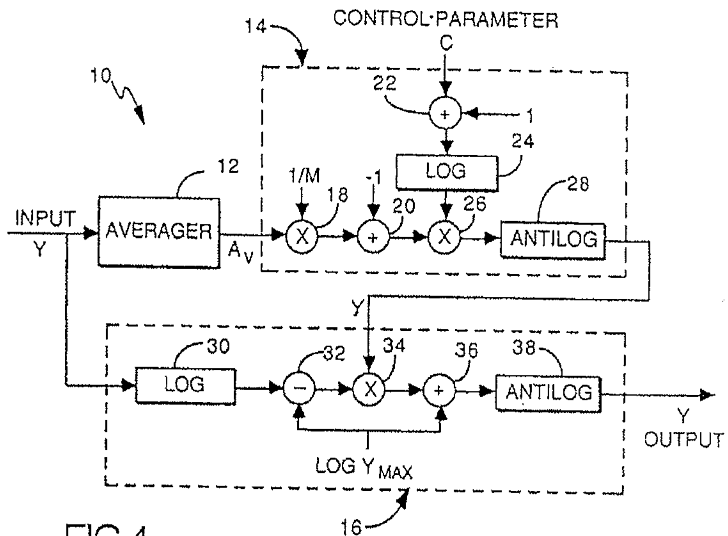
A_V

FIG 3



CONTROL·PARAMETER
C
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10
22
1
24
LOG
12
1/M
18
-1
20
26
28
INPUT
Y
AVERAGER
A_V
ANTILOG
Y
30
LOG
32
34
36
38
ANTILOG
Y
OUTPUT
LOG Y_{MAX}
16

FIG 4

SYSTEM AND METHOD FOR ELECTRONIC IMAGE ENHANCEMENT BY DYNAMIC PIXEL TRANSFORMATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a system and method for electronic image enhancement by dynamic pixel transformation and, more particularly, to a system and method for enhancing electronic image information by dynamically transforming electronic information signals on a pixel-to-pixel basis.

2. Description of the Prior Art

Electronic still image cameras are becoming well known in the art. Such cameras utilize photoresponsive arrays to sense scene light and convert the sensed scene light into electronic information signals. Electronic information signals are thereafter stored on a suitable media which may include magnetic, optical or solid state storage for subsequent retrieval and viewing. It may be desirable at some point to transform the stored image defining electronic information signals to a hard copy of the scene originally recorded. Photographic media have been suggested and used for such purposes. Difficulties arise, however, as a result of differences between the wide dynamic range of the scene originally sensed and recorded and the substantially smaller dynamic range to which a photographic print may be exposed. The wide dynamic range of luminance intensities within the scene originally recorded may thus be compressed or clipped to the substantially smaller dynamic range of the photographic print, losing detail within certain portions of the dynamic range that were otherwise visible in the original scene. Thus, it may be desirable to transform the original image defining electronic information signals in a nonlinear manner to selectively increase and/or decrease the contrast and brightness in certain portions of the scene such as those that might be brightly lit by sunlight or underlit as a result of shadows. However, no single transform function can be uniformly applied to all the image defining electronic information signals of the scene and achieve satisfying results because the lighting conditions vary across the scene.

Therefore, it is an object of this invention to provide a system and method of electronically enhancing images by dynamically increasing or decreasing contrast and brightness in selected portions of the scene that may be overlit or underlit.

It is a further object of this invention to provide a system and method of enhancing image defining electronic information signals in a dynamic manner on a pixel-by-pixel basis such that the value of each pixel is selectively transformed as a function of the average value of a plurality of pixels closely spaced about that pixel.

Other objects of the invention will be in part obvious and will in part appear hereinafter. The invention accordingly comprises a mechanism and system possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure.

SUMMARY OF THE INVENTION

A system is provided for enhancing electronic image data received in a continuous stream of electronic information signals wherein each signal corresponds to one of a plurality of succeeding pixels. The pixels collectively define the image to be recorded. Means are provided for averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each of the plurality of the pixels so averaged. Means operate to thereafter select one of the plurality of different transfer functions of electronic information signals for each of the succeeding pixels. Each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing that one pixel. The electronic information signal corresponding to each pixel is subsequently transformed by the transfer function selected for that pixel. The system responds to an average electronic information signal indicative of low scene light intensity levels by transforming electronic information signals to provide a higher contrast and/or brightness to those electronic information signals corresponding to pixels having the lowest scene light intensity levels. The system also responds to an average electronic information signal indicative of high scene light intensity levels by transforming electronic information signals to provide a higher contrast and/or lower brightness to those electronic information signals corresponding to pixels having the highest scene light intensity levels.

DESCRIPTION OF THE DRAWINGS

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with other objects and advantages thereof will be best understood from the following description of the illustrated embodiment when read in connection with the accompanying drawings wherein:

FIG. 1 is a block diagram showing the system for enhancing electronic image data in the manner of this invention;

FIG. 2 is a graphical representation showing the output electronic information signals versus the input electronic information signals;

FIG. 3 is a graphical representation showing the variation of gamma γ with different selected control parameters; and

FIG. 4 is a block diagram showing in substantially more detail a system for enhancing electronic image data of this invention in the manner of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In electronic image processing it is desirable to adjust the image contrast automatically to produce more detail in both the bright and dark areas of a scene that is recorded. The image enhancing system and method of this invention operates to both lighten the dark regions of a scene and darken the light regions of a scene by enhancing contrast to improve the detail visibility that would otherwise be lost when the electronic image signals are converted to a hard copy reproduction. Toward that end, the system and method of this invention operates to continuously enhance electronic image data received in a continuous stream of electronic information signals, each signal of which corresponds to one of the plurality of succeeding pixels which collectively define the recorded image.

Referring now to FIG. 1, there is shown a block diagram for the system of this invention in which a continuous stream of electronic information signals each corresponding to one of a plurality of succeeding pixels from the recorded image are received at terminal Y_{input}. The electronic information signals input at terminal Y_{input} may be derived in a well-known manner by a two-dimensional photosensitive array or sensor (not shown) which may comprise a high resolution charge coupled device (CCD) or charge injection device (CID). The sensor receives image scene light in any well-known manner by way of an objective lens and shutter (also not shown). The image sensing array comprises a plurality of image sensing elements or pixels preferably arranged in a two-dimensional area array wherein each image sensing pixel converts the incident image defining scene light rays into a corresponding analog electronic information signal value. Preferably, the image sensing pixels are arranged in columns and rows as is well known in the art. As will be readily understood, image sensing arrays, particularly for sensing still images, preferably comprise a large number of image sensing elements or pixels in the order of 500,000 or greater.

The two-dimensional photosensitive arrays may also be overlayed with any one of a variety of different well-known filter patterns so that each pixel provides an electronic information signal value corresponding to a particular color. For instance, the columns of the two-dimensional photosensitive array may be overlayed with any one of a red, green or blue filter stripe arranged in a repeating fashion across the face thereof. The electronic information signal value for each pixel in this arrangement thus corresponds to a particular color.

The electronic information signal values retrieved from the photosensitive array in this manner are preferably converted to luminance (Y) and chrominance, e.g., (R-Y and B-Y) signal values. For the case where the two-dimensional photosensitive array is overlayed with red, green and blue filters, the luminance electronic information signals are preferably determined by the following relationship: $Y=0.30R+0.59G+0.11B$ as is well known in the television art. The analog luminance electronic information signal values for each pixel element of the photosensitive array for the example herein described are digitized to an 8-bit binary number so as to have a dynamic integer range of from 0 - 255 within which range are 256 intensity levels and a maximum luminance value of $Y_{MAX}=255$. The electronic image detection and processing herein described so far will be recognized as being conventional and well known in the art.

The image defining electronic information signals derived in the above-described manner and preferably comprising digitized luminance signals are thereafter subjected to a gain control function which may be automatic as is well known in the art before being directed to input terminal Y_{input} of the block diagram of FIG. 1. The image defining luminance electronic information signals are thereafter averaged for selected pluralities of pixels by an averager 12. The averager 12 may comprise a low pass filter as is well known in the art which operates to provide an average value electronic information signal Av corresponding to the average luminance values for a selected window or plurality of pixels that continuously changes in correspondence with each succeeding pixel value to be enhanced. Alternatively, the averager may comprise a block average in which a

selected group or block of pixel values is averaged to provide one average value electronic information signal Av in correspondence with each pixel value of that group to be enhanced. Succeeding groups of pixel values are thereafter averaged. In the preferred mode, the selected groups of pixels are preferably selected in two dimensions from the photosensitive array.

Both low pass filtering and block averaging require a buffer memory to hold the selected groupings of pixel values for averaging as is well known in the art. The low pass filter method results in a continuing change in the average value of the electronic information signal Av for each succeeding pixel thereby providing a more accurate determination of average values for selecting the appropriate transfer function in the manner of this invention to be described. However, as will be well understood, the low pass filtering technique requires a substantially increased computational capacity in comparison to block averaging; and, therefore, block averaging, although not as highly selective as low pass filtering, may be preferred in image enhancing applications where reduced computational capacity is desired. Low pass filtering and block averaging are both well-known techniques in the electronic arts and therefore need not be described in any further detail herein.

The average value for the image defining luminance electronic information signal (Av) is thereafter provided to a gamma determining circuit 14 which determines gamma as a function of the average value input thereto in accordance with the following relationship:

$$\gamma=(1+C)(Av/M-1)$$

In the above relationship M for this example is selected to be the center value of the dynamic range of the electronic information signals. As was previously stated, the electronic signal values for this example comprise 8-bit binary numbers having a dynamic range of 256. Thus, for this example, $M=128$. However, it will be readily understood that M may be selected to be any value within the dynamic range of the electronic information signals depending upon where the least image enhancement is desired. Thus, for the case where M is selected to be at the center of the dynamic range, image enhancement will have the greatest effect near the ends of the dynamic range and the least effect toward the center of the dynamic range. Selecting the value of M to be closer to the high end of the dynamic range will decrease the effective image enhancement provided at that end by the system and method of this invention.

C is a control parameter selected in the manner of this invention to vary the amount of image enhancement that may be provided by the system and method of this invention in a manner to be more fully described in the following discussion.

The value of gamma is thereafter directed to a transfer function imposing circuit 16 which operates to impose the following transfer function on the image defining luminance electronic information signals (Y) received at input terminal Y_{input} and corresponding to each one of the succeeding pixels which collectively define the recorded image.

$$Y_{out}=Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$$

Y_{MAX} equals the highest value of the dynamic range for the electronic information signals or 255 for the example herein described. Y_{out} equals the image defining

luminance electronic information signal transformed in the manner of this invention to provide an enhanced image. As is now readily apparent, it is selected for the image defining luminance electronic information signal for each pixel as a function of a local average of image defining luminance electronic information signals for a select group or plurality of pixels closely spaced about the pixel value being enhanced or transformed. Thus, gamma γ changes continuously in correspondence with the average values from the continuous stream of succeeding image defining luminance electronic information signals so that each image defining luminance electronic information signal is enhanced or transformed by a selected one of a plurality of different transfer functions.

Referring now to FIG. 2, there is shown a graphical representation of the various transfer functions that are imposed by the transfer function circuit 16 as a function of the variation in gamma γ. For the example as shown in FIG. 2, the control parameter C is selected to equal 1 and thus it can be seen that gamma γ has a variation of from 0.5 to 2. For instance, in the situation where the average value of the image defining luminance electronic signals is high and approaches the maximum value of the dynamic range which in this example equals 255 and is indicative of a portion of the image that is extremely bright, it can be seen that gamma γ equals $1+C$ or as in the case where $C=1$, gamma $\gamma=2$ as shown in the diagram of FIG. 2. The slope of the transfer function as is readily apparent for the situation where gamma $\gamma=2$ becomes quite steep at the high end of the dynamic range (B_{in}, B_{out}) thereby providing a higher contrast to those image defining luminance electronic information signals corresponding to pixels having the highest scene light intensity levels. The slope of the transfer function for $\gamma=2$ decreases significantly at the low end of the dynamic range (A_{in}, A_{out}) thereby providing a lower contrast to those image defining luminance electronic information signals corresponding to pixels having the lowest scene light intensity levels. Since M is selected to be at the center of the dynamic range, it can be seen that the slope of the transfer function at the center of the dynamic range most closely approximates that of a straight line thereby providing the least effect on the output signal for pixels having intensity levels near the center of the dynamic range.

Conversely, in the situation where the average values of the image defining luminance electronic information signals are low approaching 0 indicative of localized areas of low scene light intensity levels, then gamma $\gamma=1$ divided by $1+C$ which equals 0.5 in the case where $C=1$. The transfer function imposed by the transfer function circuit 16 in the case where gamma γ equals 0.5 is shown graphically in FIG. 2 as comprising a substantially steep slope in the areas (A_{in}, A_{out}) where the image defining luminance electronic information signal values are low. Thus, the transfer function in this case where gamma γ equals 0.5 operates to transform the image defining luminance electronic information signals to provide a high contrast to those electronic information signals corresponding to pixels having the lowest scene light intensity levels. The slope of the transfer function for $\gamma=0.5$ decreases significantly at the high end of the dynamic range (B_{in}, B_{out}) thereby providing a lower contrast to those image defining luminance electronic information signals corresponding to pixels having the highest scene light intensity levels. Again, since M is selected to be at the center of the dynamic range, it can be seen that the slope of the transfer function at the center of the dynamic range most closely approximates that of a straight line thereby providing the least effect on the output signal for pixels having intensity levels near the center of the dynamic range. It can be seen that the transfer function imposed by the transfer function circuit 16 can have any intermediate number of transfer functions shown between the extreme end transfer functions where gamma equals 0.5 or 2.0 and that all of the transfer functions are operative for the full extent of the input dynamic range so as not to clip the input signal values.

In the situation where the average value for the image defining luminance electronic information signal values corresponds to the intermediate value of the dynamic range, gamma $\gamma=1$ and the transfer function becomes a straight line to provide a one-to-one relationship between the input and output electronic information signals with no localized increase in contrast as provided by the other transfer functions where gamma γ is either greater or less than 1. Thus, in this manner in a situation where a scene may have localized dark or bright areas, there may be provided a localized increase in the contrast to those areas to make visible details that otherwise would be lost. The transfer functions vary in correspondence with the variation in the local average scene light intensity levels so as to apply the increased contrast selectively to those light or dark portions of the scene where details are otherwise obscured.

Referring now to FIG. 3, there is shown a graphical representation of the variation in gamma γ as a function of the variation of the control parameter C. Thus, it can be seen that for a control parameter C value of 1 gamma γ varies from 0.5 to 2. If the control parameter C is selected to be 0, gamma γ remains constant at 1. Although for a typical imaging application which requires dynamic range compression, it may be satisfactory to select the control parameter C to equal 1 thereby achieving an extreme variation in gamma from 2 to 0.5, it may be desirable to increase the amount of localized contrast thereby selecting values of the control parameter C greater than 1.

Referring now to FIG. 4 where like numerals reference previously discussed components, there is shown a circuit diagram for implementing a transfer function as described in connection with FIG. 1. The aforementioned transfer function may be converted to the following relationship by taking the logarithm on both sides of the aforementioned equation.

$$\log Y_{out} = \log Y_{MAX} + \gamma(\log Y_{in} - \log Y_{MAX})$$

Similarly, the relationship for determining gamma can also be rewritten as follows:

$$\log \gamma = (Av/M - 1)[\log(1+C)]$$

These relationships can be implemented as shown by the circuit of FIG. 4. The average value of the image defining luminance electronic information signal is first directed to a multiplier circuit 18 where the signal is multiplied by 1/M where M equals one-half the dynamic range of the electronic information signals as previously discussed. The output from the multiplier circuit 18, in turn, is directed to a combining circuit 20 which operates to add a negative 1 to the output from the multiplier circuit 18. The control parameter C is directed to a combiner circuit 22 which operates to add

a positive 1 thereto. The output from the combiner circuit **22**, in turn, is directed to a log circuit **24** which provides the logarithmic value for the C+1 input thereto. The output from the logarithmic circuit **24**, in turn, is multiplied by the output from the combining circuit **20** by a multiplier circuit **26**. The output from the multiplier circuit **26**, in turn, is directed to an antilogarithmic determining circuit **28** which operates utilizing a lookup table to provide the antilogarithm creating the value of gamma γ.

The image defining luminance electronic information signal for each pixel, in turn, is directed to a logarithm determining circuit **30** in the transfer function circuit **16**. The output from the logarithm determining circuit **30**, in turn, is directed to a combiner circuit **32** which operates to subtract therefrom the logarithm for the maximum dynamic range of the electronic information signals. The output from the combiner **32**, in turn, is multiplied by multiplier circuit **34** by the value of gamma γ received from the antilogarithm determining circuit **28**. The output from the multiplier **34**, in turn, is directed to a combiner circuit **36** for addition to the logarithm of the maximum dynamic range of the electronic information signals. The output from the combiner circuit **36**, in turn, is directed to an antilogarithm determining circuit **38** to provide the transformed image defining luminance electronic information signals Y_{out} as shown. Thus, in this manner, gamma γ is determined continuously in accordance with the relationship as shown by the block diagram of FIG. **1** in a simple and convenient manner utilizing multiplication circuits, combining circuits, logarithm determining circuits, and antilogarithm determining circuits as shown in FIG. **4**. In like manner, the transfer function continuously varied in accordance with the selection of gamma may also be imposed continuously in a simple and convenient manner by circuitry comprising a logarithm determining circuit, combining circuits, multiplication circuit, and an antilogarithm determining circuit. Thus, in this manner localized dynamic contrast enhancement can be provided as a function of dynamic gamma transformation on a pixel-by-pixel basis.

Thus, the system and method of this invention provides for enhancing electronic image data in a manner involving a relatively small number of computations that can be easily calculated in a continuous manner. All of the transfer functions that can be invoked are of a continuous nature without any sharp discontinuities that could otherwise result in undesirable artifacts appearing in the final image. In addition, as previously mentioned, none of the transfer functions operate to clip any portion of the incoming electronic information signal, thus resulting in the entire dynamic range of the incoming signal being transformed.

Other embodiments of the invention including additions, subtractions, deletions and other modifications of the preferred disclosed embodiments of the invention will be obvious to those skilled in the art and are within the scope of the following claims.

What is claimed is:

1. A system for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said system comprising:

means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged; and

means for selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

2. The system of claim **1** wherein said selecting and transforming means is responsive to an average electronic information signal indicative of low scene light intensity levels for transforming the electronic information signals to provide a higher contrast to those electronic information signals corresponding to pixels having the lowest scene light intensity levels and is further responsive to an average electronic information signal indicative of high scene light intensity levels for transforming the electronic information signals to provide a higher contrast to those electronic information signals corresponding to pixels having the highest scene light intensity levels.

3. The system of claim **2** wherein said selecting and transforming means further operates to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function.

4. The system of claim **3** wherein said selecting and transforming means further operates to determine the select transfer function as a function of the determination of gamma (γ), said selecting and transforming means including means for determining gamma (γ) in accordance with the relationship

$$\gamma=(1+C)(Av/M-1)$$

where C equals said determined constant, Av equals the average electronic information signal value and M equals a select proportionate value of the dynamic range of the electronic information signals.

5. The system of claim **4** wherein said transforming means transforms the electronic information signal of each pixel in accordance with the relationship

$$Y_{out}=Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$$

where Y_{in} equals the value of the electronic information signal of the pixel to be enhanced, Y_{out} equals the enhanced value of the input electronic information signal and Y_{MAX} equals the highest value of the dynamic range for the electronic information signals.

6. A system for enhancing electronic image data received in a continuous stream of electronic information signals each signal having a value within a determinate dynamic range of values and corresponding to one of a

plurality of succeeding pixels which collectively define an image, said system comprising:

means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged;

means for dividing each of the average electronic information signals corresponding to each pixel by a value M corresponding to a select proportionate value of the dynamic range of said electronic information signals;

first means for subtracting 1 from each of the electronic information signals output by said dividing means;

first means for adding a select control parameter and 1;

first means for determining the logarithm of the output from said first adding means;

first means for multiplying the output from said first logarithm determining means by the output from said first subtracting means;

first means for determining the antilogarithm of the output from said first multiplying means;

second means for determining the logarithm for each of the continuous streams of electronic information signals;

second means for subtracting the logarithm for a value corresponding to the maximum value of the electronic information signals from the output of said second logarithm determining means;

second means for multiplying the output of said first antilogarithm determining means by the output from said second subtracting means;

second means for adding the logarithm of the value corresponding to the maximum value of the electronic information signals to the output from said second multiplying means; and

second means for determining the antilogarithm of the output from said second adding means to provide an enhanced output signal value.

7. A method for continuously enhancing electronic image data received in a continuous stream of electronic information signals each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:

averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels;

selecting one of a plurality of different transfer functions for the electronic information signal for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel; and

transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said transfer function is selected further as a function of the ratio of the value of the average electronic information signal to a select proportionate value of the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

8. The method claim 7 wherein the transfer function is selected: in response to an average electronic information signal indicative of low scene light intensity levels to provide a higher contrast to those electronic information signals corresponding to pixels having the lowest scene light intensity levels and in response to an average electronic information signal indicative of high scene light intensity levels to provide a higher contrast to those electronic information signals corresponding to pixels having the highest scene light intensity levels.

9. The method of claim 8 wherein said transfer function is selected further as a function of a determined constant wherein increasing the value of said constant operates to increase the contrast in those areas of higher contrast provided by said select transfer function.

10. The method of claim 9 wherein said transfer function is selected as a function of the determination of gamma (γ) and gamma (γ) is determined for each pixel in accordance with the relationship

$$\gamma=(1+C)(Av/M-1)$$

where C equals said determined constant, Av equals the average electronic information signal value and M equals said value for one-half the dynamic range of the electronic information signals.

11. The method of claim 10 wherein said select transfer function for the electronic information signal of each pixel comprises the relationship

$$Y_{out}=Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$$

where Y_{in} equals the value of the electronic information signal of the pixel to be enhanced, Y_{out} equals the enhanced value of the input electronic information signal and Y_{MAX} equals the highest value of the dynamic range for the electronic information signals.

12. A method for enhancing electronic image data received in a continuous stream of electronic information signals each signal corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:

averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels;

dividing each of the average electronic information signals corresponding to each pixel by a value M corresponding to a select proportionate value of the dynamic range of said electronic information signals;

subtracting 1 from each of the electronic information signals previously divided by the value M to provide a first intermediate signal value;

selecting a control parameter C as a function of the amount of image enhancement to be applied;

adding 1 to the control parameter C;

determining the logarithm of the control parameter C plus 1;

multiplying the logarithm of the control parameter C plus 1 by said first intermediate signal value to provide a second intermediate signal value;

determining the antilogarithm of the second intermediate signal value;

determining the logarithm for each of the continuous streams of electronic information signals;

subtracting from the previously determined logarithm for each of the continuous streams of electronic information signals the logarithm for a value corresponding to the maximum value of the electronic information signals to provide a third intermediate signal value;

multiplying the antilogarithm of the second intermediate signal value by the third intermediate signal value to provide a fourth intermediate signal value;

adding the logarithm of the value corresponding to the maximum value of the electronic information

signals to the fourth intermediate signal value to provide a fifth intermediate signal value; and

determining the antilogarithm of the fifth intermediate signal value to provide an enhanced output signal value.

13. The method of claim **12** wherein said image enhancement operates to increase image contrast locally in areas of pixels having low contrast and said control parameter C is determined as a function of the amount of local contrast variation to be provided.

* * * * *

Exhibit 7

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Exhibit 8

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Exhibit 9

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Exhibit 10

IS&T/SID Eighth Color Imaging Conference

Local Color Correction Using Non-Linear Masking

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Abstract

Tone reproduction is a key component in image quality and historically tone correction has been performed on a global basis for a given device or image. Several recent investigations have used a variety of algorithms to demonstrate that local color correction provides a significant improvement in image quality relative to a global correction. This paper presents a local color correction operation that is based on non-linear masking. The operation is very fast and does not require any manual adjustments, such as those involved in dodging and burning. The algorithm is roughly equivalent to deriving a specific tone reproduction curve for each pixel in the image. An example image is processed using the proposed masking scheme and the resulting effect is discussed. Finally, the relationship to CIECAM97s is explored and it is proposed that dynamically setting the background parameter results in similar local color corrections.

Introduction

Tone reproduction is a critical aspect of the perceived quality of a reproduction.[1] Historically tone corrections have been global one-dimensional operations in which one input value maps to one and only one output value. [2] This approach results in a reasonable correction if the original dynamic range is fairly close to the dynamic range of the reproduction. For a much larger dynamic range original it becomes increasingly difficult to design a global tone correction that will accommodate both shadow and highlight detail.

Therefore, there has been ongoing research[3-15] in the area of local color correction and processing high dynamic range images. A local color correction will provide a method to map one input value to many different output values, depending on the values of neighboring pixels. This allows for simultaneous shadow and highlight adjustments. It is beyond the scope of this paper to provide a comparison of the previously proposed algorithms for local color correction. However, some limitations that have been encountered in some cases are computational complexity, lack of calibration procedure, "halo" artifacts, iterative processing, segmentation failures, lack of direct control parameters, incompatibility with look up table processing or requiring manual adjustments.

This paper demonstrates a local color correction technique that is simple, fast and comparable to the other local color correction methods.[3-15] This method uses non-linear masking in order to perform local color correction. [16] It should be noted that initial investigations of this method of local color correction were not based on any model of visual perception. To illustrate, traditional unsharp masking provides a powerful tool to sharpen images but care should be taken not to attribute the functionality of the algorithm to specific aspects of the human visual system. The proposed masking algorithm provides a simple, computationally efficient and easily parameterized framework for performing local color corrections.

Local color correction is also useful for enhancing or improving certain types of images. To illustrate, conventional photography may yield an image in which one region of the image is underexposed while another region is correctly exposed. Flash photography is another instance in which one region in the image may be over-exposed while another is under-exposed. Correcting for failures during image capture or for illumination fall-off are not, strictly speaking, the goals of a vision model. Aesthetic and contextual issues further complicate the issue of local color correction but will not be considered in this paper.

Basic Algorithm

The first part of the proposed algorithm consists of the derivation of an image mask. The second part of the algorithm is the combination of the mask and the input image. This is shown in flowchart form in Figure 1 where one operator computes the mask and the other combines the mask and the input image. In this paper, the mask is simply an inverted low-pass filtered monochrome version of the input image. The combination operation is then a variable power function where the exponent is computed from the mask.

The mask can be computed by taking an image and converting it to a monochrome image. This monochrome image is then inverted and finally the image is blurred using a large radius filter. The mask is monochrome in order to avoid distorting the chroma of the image. The image is inverted to indicate which regions of the image

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will be lightened or darkened. For example, a dark region in the image will have a light mask value and will therefore be lightened. However, a positive mask can also be used as will be discussed in a following section. The image should be blurred such that image features can no longer be recognized. For instance, a 72 dpi monitor image could be blurred using a gausssian blur with a radius of 15 pixels. If the mask is not blurred, then the image contrast will be excessively reduced. In comparison, if the mask is overly blurred then this algorithm reduces to simple gamma correction. A computationally efficient implementation can use an image thumbnail or a significantly sub-sampled image in order to compute the mask.

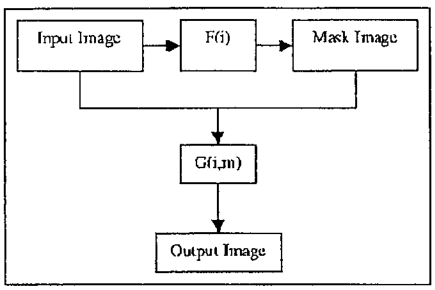

Figure 1. Basic flowchart for non-linear masking.

The combination operation consists of a simple power function where the exponent is computed using the mask value. Mask values greater than 128 will result in an exponent less than 1 while mask values less than 128 will yield exponents greater than 1. Mask values of 128 will result in a mask value of 1 and will not change the input data. Example curves showing how input values are mapped to output values as a function of the mask value are shown in Figure 2. This operation essentially consists of performing a pixel-by-pixel gamma correction. This can be written as the following equation:

$$Output = 255 * \left(\frac{Input}{255} \right)^{\left(2^{\left(\frac{128 - Mask}{128} \right)} \right)} \quad (1)$$

Equation 1 can be implemented as a fully populated two dimensional table where the input and mask values are the input and the output is the pre-calculated value for that combination. Furthermore, the equation can easily be modified to adjust the identity value or the range of the exponents. This would be useful for a limited parameter adjustment based on user preferences or even image properties. This tone reproduction surface can be thought of as a two-dimensional version of a tone reproduction curve.

There are a number of intriguing variations on the mask derivation and combination operators. However, the method described demonstrates one of the simplest techniques for performing local color correction using non-linear masking. Notice that while the mask derivation process may be similar to that used during the traditional process of unsharp masking, the non-linear combination operation is much different than the additive operation used during unsharp masking and therefore results in local color adjustments.

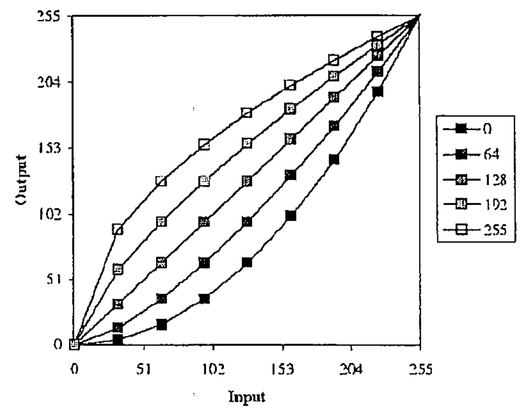

Figure 2. Example curves showing how input 8 bit RGB values are mapped to output values as a function of the mask value.

Results

The results of local color correction using masking are shown in Figures 3. This figure shows an original black and white image on the top. The figure in the image is slightly underexposed but a global tone curve to correct the figure would reduce the highlight detail in the sky. Below the original image is the mask as computed using the previously described technique. It is interesting to note the similarity of the mask image to a negative afterimage.[17] The bottom is the corrected image. Note that light regions in the image correspond to dark regions in the mask and are darkened in the corrected image. Conversely, dark regions in the image correspond to light regions in the mask and are lightened in the corrected image.

The fence behind the boy in Figure 3 is changed without any overshoot or ringing around the edges. In addition, the image has a white border and even this strong edge does not introduce any distortions. This is a result of two factors. First, the non-linear masking is bounded at the extremes so that the white and black points of the image are never adjusted regardless of the mask values. This means that the correction will be less at the extremes, where haloing may be more common. Second, the low pass nature of the mask means that tone corrections will occur slowly over the image. These gradual transitions result in local tone adjustments that are not obvious for complex images or regions. For simple images or regions on the other hand the mask is simple and in the extreme reduces to a simple global tone correction.

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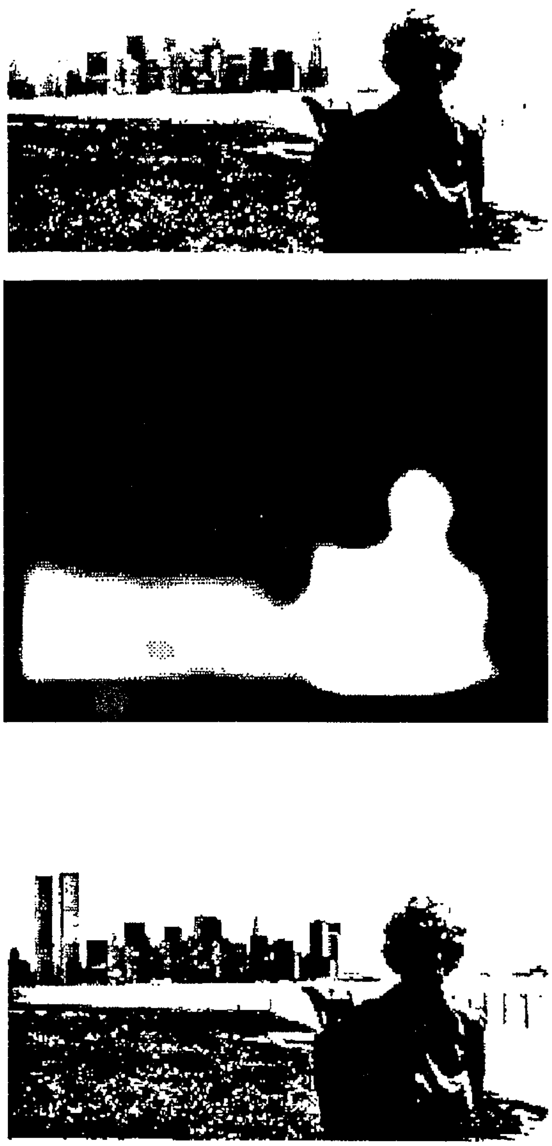

Figure 3. Original, mask and locally color corrected image shown from top to bottom. The original image has a white border surrounding the image.

Discussion

Equation 1 is very similar to the CIECAM97s[18] formula for lightness. In this case J or lightness is a function of the luminance of the background, as well as other parameters. Fairchild notes that "specification of the background is absolutely necessary for modeling simultaneous contrast".[19] A simplified form of CIECAM97s lightness can be written:

$$J = 100\left(\frac{A}{A_W}\right)^{c_1\left(1+c_2\left(\frac{Y_b}{Y_w}\right)^{1/2}\right)} \qquad (2)$$

where c1 and c2 are viewing condition parameters that result in an exponent that ranges from 0.69 to about 1.38 for an average surround. The form of this equation with the normalization, exponent and scaling is very similar to equation 1.

Equation 2 yields a family of lightness curves for a range of background luminances. This is shown in figure 4 and can be compared with figure 2. The CIECAM97s local color correction uses a positive mask and therefore the order of white to black backgrounds is reversed. Equation 1 can also be modified to assume a positive mask but the author finds working with a negative mask is useful for assessing where the image will be lightened and darkened by looking at the mask. The positive mask is used for CIECAM97s because of the perceptual significance of Yb.

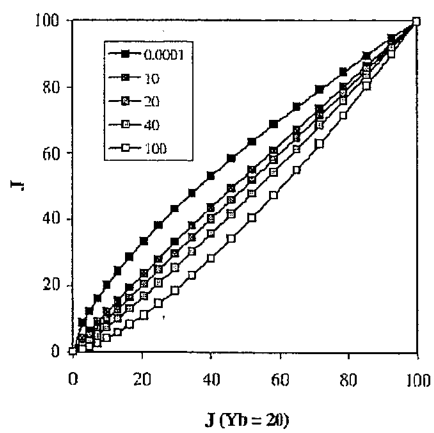

Figure 4. Family of lightness curves for various CIECAM97s background or Yb settings. The lightness for a given background is plotted against the lightness for Yb of 20.

A non-linear masking operation similar to that previously described can be performed using CIECAM97s. The images are first converted to CIECAM97s J, a_{c97}, b_{c97} coordinates and then a positive lightness mask is computed using the J channel of the image. The resulting images are similar to those previously generated using just an exponential operator on the RGB channels. This demonstrates that local color correction can be computed using

CIECAM97s and the result is an image in which highlights can be darkened and shadows lightened in one step. This processing does not require segmentation or iteration and is based on the results of psychophysical observations. Furthermore, using CIECAM97s instead of a device RGB provides a method of calibrating the local color correction.

There are numerous possible applications of this type of processing. One application is to better map high dynamic range scenes to lower dynamic range display and output devices. Another application is to correct for non-uniform illumination, such as flash photography, backlit subjects or flat-bed scans of three-dimensional objects. This type of processing can also be used given an original that has regions that are incorrectly exposed. This type of color correction can also be used for aesthetic purposes, such as to reduce differences in illumination when compositing

Conclusion

Local color correction can be performed using non-linear masking. This correction can simultaneously lighten shadows and darken highlights and is based on a simple pixel-wise "gamma" correction of input data. Using a low pass inverted monochrome version of the original will balance global and local contrast changes and reduce chroma distortions. This algorithm can be used for images with uneven exposure or flash illumination. It can also be used for object scanning and adjusting high dynamic range scene data during scene rendering. While there are a number of alternative algorithms for performing local color correction, it is interesting to note the relative simplicity of the proposed algorithm and its close relationship to the lightness scale that is incorporated in the CIECAM97s color appearance model. This implies that it may be useful to consider constructing a color appearance model from near to far.

Local color correction would seem to be a complementary technology to traditional pixel based processing. For example, once the image has been corrected it can then be reproduced on a given printer using a traditional pixel based pipeline. Use of a neighborhood image processing technique for one part of the imaging pipeline does not exclude subsequent pixel based image processing. This suggests that pixel and neighborhood imaging operations could be used where appropriate to optimize the overall quality and speed of the imaging pipeline.

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Biography

Nathan Moroney is a color scientist in the Color Imaging and Printing Technologies Department of Hewlett-Packard Laboratories. Previously, he worked for the Barcelona division of Hewlett-Packard and at the RIT Research Corporation. He has a Bachelors degree in color science from the Philadelphia University and a Masters degree in color science from the Munsell Color Science Laboratory of RIT. His research interests include color appearance models and color variability. He is currently the technical chair for CIE TC8-01.

Exhibit 11

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Exhibit 12

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HP Invests More Than $1 Billion to Reset Printing and Imaging Market

Company's Largest Consumer Product Rollout in History Sparks Digital Imaging Revolution -- Putting Traditional Photography on Alert

NEW YORK, TechXNY/PC Expo, June 25, 2002

HP (NYSE: HPQ) today unveiled its $1.2 billion investment to reset the imaging and printing market. Between now and early 2003, HP will roll out worldwide more than 50 new imaging and printing products offering consumers greater value and unparalleled ease of use.

The company has invested $900 million in manufacturing, $125 million in research and development and $200 million in marketing to roll out the single largest consumer product launch in the company's history and drive digital imaging mainstream.

"This announcement marks a defining moment in the evolution of HP's imaging and printing business," said Carly Fiorina, HP chairman and chief executive officer. "Today's announcement is the upshot of a major R&D and manufacturing effort designed to make technology a more natural extension of how we live and work by engineering our products explicitly for simplicity and ease of use."

"Today's announcement culminates a three-year investment to make the process of taking, printing and sharing photos easier and more affordable for consumers," said Vyomesh Joshi, executive vice president, HP Imaging and Printing Group. "This effort included completely redesigning our products and supplies to meet the emerging needs of consumers as digital imaging becomes pervasive."

HP begins delivering on its investment with today's announcement of three new printers, the HP Deskjet 5550, 3820 and 3420 color inkjet printers.

The new HP Deskjet 5550 color inkjet printer produces images that rival the quality of traditional photographs. It features up to six-ink printing with HP's exclusive color layering technology from Photoret IV(1) and 4,800-optimized dots-per-inch (dpi) technology.(2) Photoret IV enables the HP DeskJet 5550 color inkjet printer to produce more than 1.2 million colors that create images with natural, lifelike skin tones and bright, vibrant colors at a quality unmatched by any other personal printer available today.

HP also announced two printers priced below $100 that address the increasing demand for affordable and reliable high-quality printing. They are the HP Deskjet 3420 color inkjet printer and the HP Deskjet 3820 color inkjet printer, which features 4,800-optimized dpi.

IDC predicts that by 2005, more than 15 billion digital images will be printed in the United States and over one-third of U.S. households will own digital cameras.(3) A recent InfoTrends study shows that 81 percent of people intending to purchase a digital camera expect to print their digital photos at home.(4)

HP invented thermal inkjet technology in 1979, and in 1984 the company produced the industry's first thermal inkjet printer, the HP ThinkJet printer. Since then, HP has continued to make personal printing better, easier and more accessible to consumers -- a strategy that has enabled HP to lead the printer market for more than 18 years.

"Twenty years and 170 million inkjet printers later, HP continues to reinvent inkjet technology," said Angele Boyd, group vice president, Image Capture and Output Research, IDC. "By bringing higher

levels of photo-quality printing to the lowest price points in its product line, HP reinforces its leadership not only in the high-end, but in the low-end segment as well."

HP Deskjet 5550 Color Inkjet Printer

The HP Deskjet 5550 color inkjet printer offers versatile photo and document printing with standard four-ink or optional six-ink color printing, fast speeds and convenient, innovative features such as borderless 4 x 6-inch photo printing and ink-backup mode. The printer prints laser-quality black text at up to 17 pages per minute (ppm) and color at up to 12 ppm on a wide variety of paper types and sizes.

The HP Deskjet 5550 color inkjet printer ships with the new HP 56 Black inkjet print cartridge and the HP 57 Tri-color inkjet print cartridge, providing crisp black text and brilliant color, four-ink printing.

Optional six-ink color printing is available with the separate purchase of the new HP 58 Photo inkjet print cartridge, which, when used with the HP 57 Tri-color inkjet print cartridge, provides six-ink, virtually grain-free photos with excellent fade resistance on photo paper.

HP Deskjet 3820 Color Inkjet Printer

The HP Deskjet 3820 color inkjet printer features 4,800-optimized dpi and print speeds of up to 12 ppm in black and 10 ppm in color.(2) With 4,800-optimized dpi, consumers can enjoy stunning photo quality and rich black text. In addition, users can save time and money with "smart" features such as the print-cancel button, an ink-level indicator and manual two-sided printing.

The HP Deskjet 3820 color inkjet printer allows consumers to link multiple home computers to a single printer with optional HP Jetdirect wired and wireless print accessories.

The HP Deskjet 3820 color inkjet printer is compatible with the HP 15 Black inkjet print cartridge and the HP 78 Tri-color inkjet print cartridge.

HP Deskjet 3420 Color Inkjet Printer

The HP Deskjet 3420 color inkjet printer offers families and personal users fast speeds and enhanced print quality with 2,400-dpi color printing at up to 10 ppm in black and eight ppm in color. Also, by using HP's specially developed inks and papers, consumers can print long-lasting photos to preserve their favorite memories.

The printer features on-screen monitoring that saves consumers time and money by displaying a warning when the printer is low on ink, while the on-screen print-cancel button allows consumers to stop a job with the click of a button.

The HP Deskjet 3420 color inkjet printer is compatible with the new HP 27 Black inkjet print cartridge, providing laser-quality black text for the home user, and the new HP 28 Tri-color inkjet print cartridge, providing brilliant photo quality and color graphics for the home user.

Price and Availability

The HP Deskjet 5550, 3820 and 3420 color inkjet printers are expected to begin shipping in early July. Estimated U.S. street prices are as follows: HP Deskjet 5550 color inkjet printer -- $149, HP Deskjet 3820 color inkjet printer -- $99, HP Deskjet 3420 color inkjet printer -- $79.(5)

About HP

HP is a leading global provider of products, technologies, solutions and services to consumers and businesses. The company's offerings span IT infrastructure, personal computing and access devices, global services and imaging and printing. HP completed its merger transaction involving Compaq Computer Corp. on May 3, 2002. The company would have had combined revenue on a pro forma basis with the Compaq transaction of approximately $81.1 billion in fiscal 2001 and has operations in more than 160 countries. More information about HP is available at http://www.hp.com.

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(1) HP Photoret IV is enabled in six-ink printing, available with separate purchase of photo cartridge; not included.

(2) Up to 4,800 x 1,200-optimized dpi color printing on premium photo papers with 1,200 x 1,200-input dpi.

(3) IDC, "The Impact of Digital Image Capture on the US Photofinishing Industry, 2000-2005," published May 2001.

(4) InfoTrends, "2002 Digital Camera Survey: Strong Momentum for Digital Camera Adoption," published March 2002.

(5) Actual prices may vary.

This news release contains forward-looking statements that involve risks, uncertainties and assumptions. All statements other than statements of historical fact are statements that could be deemed forward-looking statements. Risks, uncertainties and assumptions include the possibility that the market for the sale of certain products and services may not develop as expected; that development of these products and services may not proceed as planned; and other risks that are described from time to time in HP's Securities and Exchange Commission reports, including but not limited to HP's annual report on Form 10-K, as amended on January 30, 2002, for the fiscal year ended October 31, 2001, HP's quarterly report on Form 10-Q for the quarter ended January 31, 2002 (as filed with the SEC on March 12, 2002) and subsequently filed reports. If any of these risks or uncertainties materializes or any of these assumptions proves incorrect, HP's results could differ materially from HP's expectations in these statements. HP assumes no obligation and does not intend to update these forward-looking statements.

Exhibit 27

News release

Digital Imaging "Takes the Cake" at Star Wars-themed Wedding

HP Digital "Do-over" Contest Winners Announced

PALO ALTO, Calif., Aug. 14, 2002

A short time ago in a galaxy not too far away (Vancouver, Wash.), a young couple missed capturing the moments of their Star Wars-themed wedding due to common mishaps associated with traditional film cameras: red-eye, cropped heads and out-of-focus shots. Fortunately, Lynnel and Josh Stroder, winners of the HP Digital "Do-over" Contest, will get a chance to recapture their special day with a wedding do-over valued at up to $10,000.

"Many photo mishaps associated with traditional film cameras, like the ones the Stroders experienced, can be avoided with digital photography, which offers users greater choice, control and convenience when capturing and sharing their 'magic moment,'" said Jeff Hopper, general manager of marketing, HP Digital Imaging Organization. "HP's digital photography solutions allow users the choice to select only the images they want, the control to fix problems such as red-eye and the convenience to immediately share the image whether that's via e-mail or printing the photo right on the spot.

"HP is happy to provide the Stroders with the opportunity to re-do their event along with HP digital imaging products that will help them successfully capture and share keepsake photos easier in the future."

The first runner-up, Kathy Page, a long-time fan of President Bush, saw sadly a photo of the President -- and him alone -- when her boss, Sen. John Ensign of Nevada, failed to capture a once-in-a-lifetime image of her with the President at an event in Washington, D.C. While she has a lot of respect for her boss, she offers him six words of advice, "Senator, don't quit your day job!"

The second runner-up, Mary Ellen Usimaki, found that her parents' 50th wedding anniversary wasn't so "golden" when she and her siblings failed to capture any good shots of their parents' milestone celebration. She received her photos back only to view "a bunch of overly dark and overly light shots, shots with chopped off heads and missing body parts, shots too far away, and a roll of double exposed film."

All three winners will receive HP digital imaging products, including the HP Photosmart 812 digital camera, HP Photosmart 7550 printer and HP Scanjet 3570 scanner, that will ensure that next time they will safely and easily capture, share, save and print their images.

The HP Digital Do-over Contest was designed to give people the chance to benefit from their nightmare photo-taking experiences and learn more about the advantages of digital imaging. Each entrant submitted an essay describing a "missed" special event photo experience. Judges selected the winners from hundreds of entries based on the magnitude of the nightmare experience and the informative and entertaining nature of the entry. The winners' full stories are located at http://www.hp.com/go/digitaldo-overcontest.

Among the entries, the majority of "missed" moments happened with vacation photos (46 percent). Other photo mishaps included: weddings (28 percent); family functions (10 percent); births of a baby, honeymoons, anniversaries (each 5 percent); and reunions (2 percent). Most of the mishaps (55 percent) were related to the loading and advancing of film (for example, not installing film, film not advancing, using wrong film speed, loading used film). Other issues included: film processing -- lost film or ruined film (25 percent); overexposed or underexposed images (29 percent); and blurry photos (21 percent).

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Exhibit 28

user's guide

To find an answer to a question, select one of the topics below:

notices

- notices and acknowledgements
- terms and conventions
- accessibility

notices and acknowledgements

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terms and conventions

The following terms and conventions are used in the *user's guide*.

terms

The HP Deskjet printer may be referred to as the **HP printer** or **printer**.

symbols

The **>** symbol guides you through a series of software steps. For example:

Click File > Print.

cautions and warnings

A **Caution** indicates possible damage to the HP Deskjet printer or to other equipment. For example:

> Caution! Do not touch the print cartridge ink nozzles or copper contacts. Touching these parts will result in clogs, ink failure, and bad electrical connections.

A **Warning** indicates possible harm to you or to others. For example:

> Warning! Keep both new and used print cartridges out of the reach of children.

icons

A **Note** icon indicates that additional information is provided. For example:

> For great results use HP products.

A **Mouse** icon indicates that additional information is available through the **What's This?** help feature. For example:

> To find more information about options on each tab screen, point to an option and click the right mouse button to display the **What's This?** dialog box. Click **What's This?** to view information about the selected option.

A **Do Not** icon indicates that an action is not recommended.

Do not clean the interior of the printer.

accessibility

Your HP printer provides a number of features that make it accessible for people with disabilities.

visual

The printer software is accessible for users with visual impairments or low vision through the use of Windows accessibility options and features. It also supports most assistive technology such as screen readers, Braille readers, and voice-to-text applications. For users who are color blind, colored buttons and tabs used in the software and on the HP printer have simple text or icon labels that convey the appropriate action.

mobility

For users with mobility impairments, the printer software functions can be executed through keyboard commands. The software also supports Windows accessibility options such as StickyKeys, ToggleKeys, FilterKeys, and MouseKeys. The printer doors, buttons, paper trays, and paper guides can be operated by users with limited strength and reach.

support

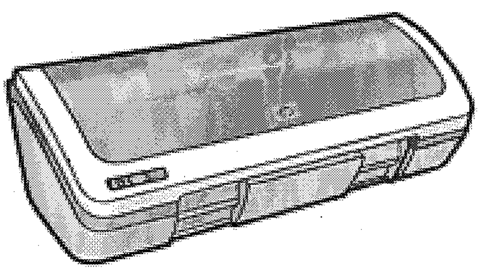
For more details about the accessibility of this product and HP's committment to product accessibility:

- Visit HP's Web site at: www.hp.com/accessibility
- Email HP at: accessibility@hp.com

special features

Congratulations! You have purchased an HP Deskjet printer that is equipped with several exciting features:

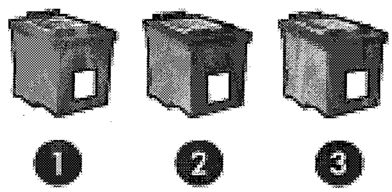
- **Brilliant photo-quality printing**: Great printing performance with the black and tri-color print cartridges installed.
- **Six-ink upgradeable printing**: Enhance photo printing with a photo print cartridge (purchased separately).
- **Borderless printing**: Print 4 x 6 inch photos and cards to the edges of the paper using the borderless printing feature.
- **User friendly**: Easy to install and operate.
- **Cancel button**: Save paper and ink by cancelling print jobs quickly and easily with the Cancel button.
- **Ink level indicator**: Know the approximate ink level of each print cartridge with the onscreen ink level indicator.
- **Compact**: Small, lightweight, and easy to set up, store, or carry.
- **Quality**: Built to give you the best results for your printing needs.



print cartridges

Three print cartridges can be used with the printer.

- black print cartridge
- tri-color print cartridge
- photo print cartridge



1. black print cartridge 2. tri-color print cartridge 3. photo print cartridge

Not all print cartridges may be packaged with your printer.

print cartridge selection

printer model	print cartridge	selection number	product number
HP Deskjet 3600 Series (except HP Deskjet 3658/3668)	black	**27**	c8727
	tri-color	**28**	c8728
	photo	**58**	c6658
HP Deskjet 3658/3668	Please refer to the graphic instructions located under the printer cover, or the hardcopy *reference guide* that was included with your printer.		

For installation instructions, click here .

For storage instructions, click here .

For recycling instructions, click here .

For print cartridge ink capacity, see the information included in the print cartridge packaging.

For great performance from your HP printer, use only genuine, factory-filled HP print cartridges.

printing digital photographs

The printer has several features to enhance the quality of digital photographs.

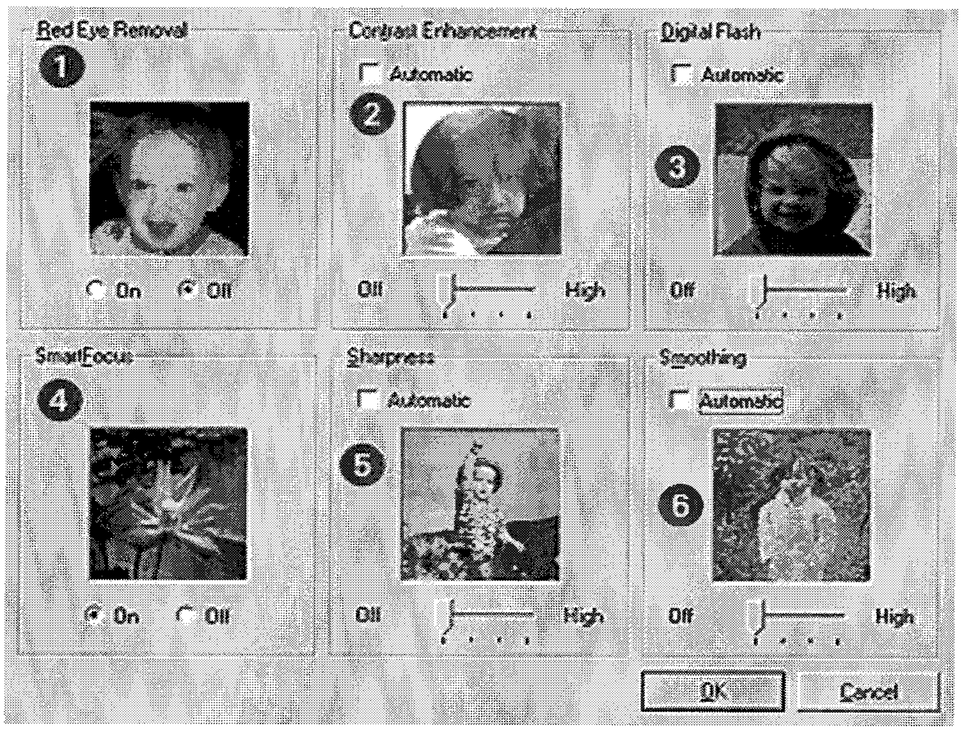
opening the hp digital photography options dialog box

Follow these steps to open the hp Digital Photography Options dialog box:

1. Open the Printer Properties dialog box.
2. Click the Paper/Quality tab, then click the hp Digital Photography button.

using the hp digital photography options dialog box

Use the hp Digital Photography Options dialog box to set these options:



1. **Red Eye Removal**: Click On to remove or reduce red-eye from the photograph.
2. **Contrast Enhancement**: Adjust contrast to preference. Click Automatic to allow the printer driver to automatically balance the contrast.
3. **Digital Flash**: Lighten dark images. Click Automatic to allow the printer driver to automatically balance lightness and darkness.
4. **SmartFocus**: Click On to allow the printer driver to automatically focus

images.

5. **Sharpness**: Adjust image sharpness to preference. Click Automatic to allow the printer driver to automatically sharpen the image.
6. **Smoothing**: Adjust distortion to preference. Click Automatic to allow the printer driver to automatically smooth the image.

Exhibit 29

user's guide

To find an answer to a question, select one of the topics below:

- notices
- special features
- getting started
- connectivity
- printing
- maintenance
- troubleshooting
- specifications

notices

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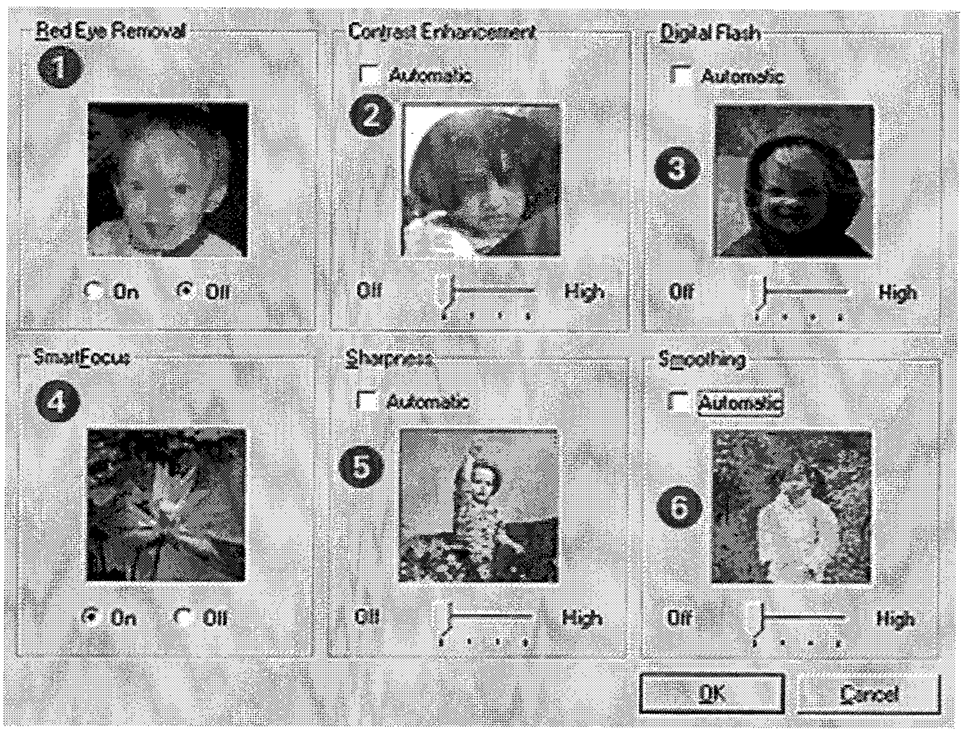
using the hp digital photography options dialog box

Use the hp Digital Photography Options dialog box to set these options:



1. **Red Eye Removal**: Click On to remove or reduce red-eye from the photograph.
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4. **SmartFocus**: Click On to allow the printer driver to automatically focus images.
5. **Sharpness**: Adjust image sharpness to preference. Click Automatic to allow the printer driver to automatically sharpen the image.

6. **Smoothing**: Adjust distortion to preference. Click Automatic to allow the printer driver to automatically smooth the image.

Exhibit 30

user's guide

To find an answer to a question, select one of the topics below:

- notices
- special features
- getting started
- connectivity
- printing
- maintenance
- troubleshooting
- specifications

notices

- notices and acknowledgements
- terms and conventions
- accessibility

notices and acknowledgements

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printing digital photographs

The printer has several features to enhance the quality of digital photographs.

opening the hp digital photography options dialog box

Follow these steps to open the hp Digital Photography Options dialog box:

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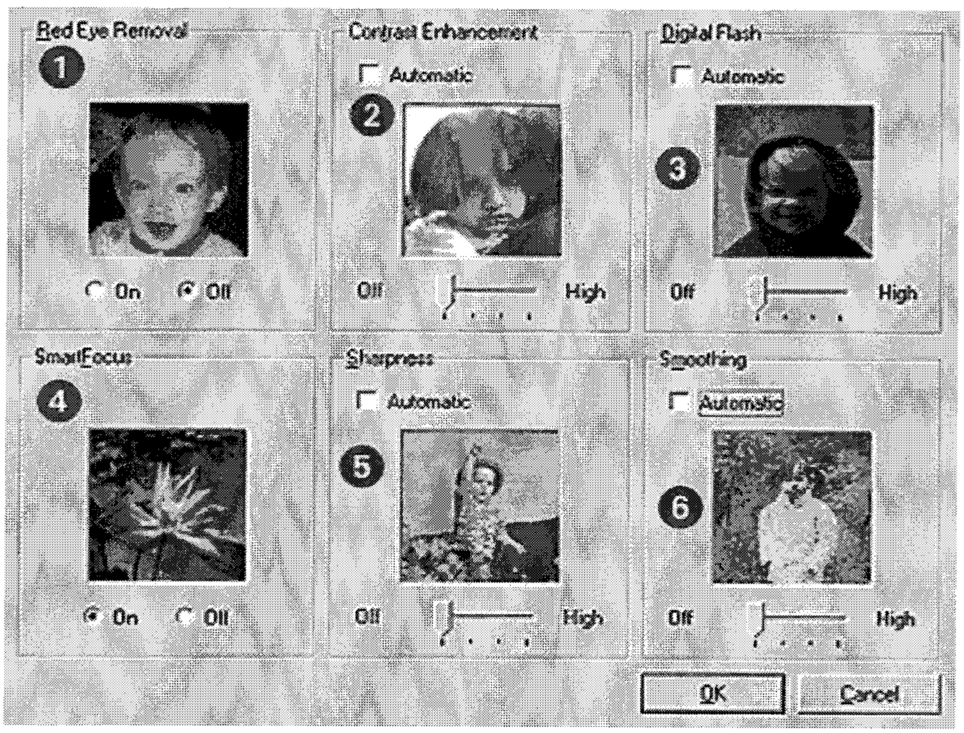
using the hp digital photography options dialog box

Use the hp Digital Photography Options dialog box to set these options:



1. **Red Eye Removal**: Click On to remove or reduce red-eye from the photograph.
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4. **SmartFocus**: Click On to allow the printer driver to automatically focus

images.

5. **Sharpness**: Adjust image sharpness to preference. Click Automatic to allow the printer driver to automatically sharpen the image.
6. **Smoothing**: Adjust distortion to preference. Click Automatic to allow the printer driver to automatically smooth the image.

Exhibit 31

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Exhibit 32

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Exhibit 33

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Exhibit 34

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Exhibit 35

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Exhibit 36

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Exhibit 37

CNN.com

CNN.com

August 13, 2003 Wednesday

SECTION: TECHNOLOGY

LENGTH: 1171 words

HEADLINE: 'Is HP the New Apple?'

BYLINE: David Kirkpatrick ; FORTUNE.COM

BODY:

It's a comparison HP is happy for consumers to make. With its massive new product rollout, the company is challenging competitors to keep up. In an interview with Fortune.com, HP CEO Carly Fiorina says the company's aim is not the next killer app -- but making tech work better for its customers.

"Is HP the new Apple?" Omar Wasow leaned over and asked me during the company's massive product launch in New York Monday. He is NBC's tech impresario who advises Oprah and directs BlackPlanet.com. I told him I had only minutes before written in my notebook, "HP moving to become the Apple of the PC world."

It's a comparison HP willingly invited as it introduced 158 new products all at once -- from printers to PCs to cameras to inexpensive photo paper. Apple of course has led the way toward a vision of integrated digital consumer devices and software for imaging, music, and video. But HP, said CEO Carly Fiorina onstage, didn't merely want to "think different," in an allusion to Apple's marketing slogan, but to "rethink everything."

That was overstatement, but many of HP's new products really were innovative -- like the PC that had a built-in camera holder. Slip your HP digital camera into it, press one button, and pictures are on your PC. Press another button and they're printed (if your printer is hooked up right). CEO Carly Fiorina bragged onstage that this represented the fulfillment of HP's promise in January 2002 to reduce the steps required for taking and printing digital images from 58 to 3. I'm sure they were generous in their initial count, but regardless, they have made things easier. Another cool technology is what they call **"adaptive lighting."** It compensates on the camera for underlit or overlit portions of a photo so that the resulting picture is properly exposed throughout. **HP** also launched a scanner that is basically two pieces of glass surrounded by plastic. Hold it up to anything and it will scan it into your PC--almost like a camera.

Technology for the masses

"Simple integrated technology not for the geeks -- for the masses." That's how Fiorina described the mission of Hewlett-Packard in my interview with her shortly after the company's presentation. She argued that this giant consumer launch, to be supported by a $300 million marketing campaign this fall, fits in clearly with an overall company strategy. "In September 2001 when we announced our merger with Compaq, I said customers aren't interested in stand-alone boxes or killer apps anymore," she said. "They want it all to work better." She said yesterday's announcement was about making it all work better in the home, just as HP's "adaptive enterprise" strategy for business customers aims to make tech work together better there. "The theme of simplifying and integrating is common in every market we serve."

Monday was certainly a stake in the ground for a fundamentally new approach. And HP clearly has advantages, aside from its dazzlingly impressive CEO, who seems more confident every day. Its overwhelming dominance in printers is beginning to seem a more significant competitive advantage over rivals than most of us had previously realized.

Of course that business garners and protects precious shelf space, but as more and more printing moves into the home (will magazines be next?) owning the printer franchise becomes strategic, partly because more and more devices have to work with the printer. And who of HP's competitors deploys a comparable range of products? Fiorina challenged me to name one, and I couldn't. Apple and Sony, the two companies that have the most similar strategic vision for how consumers will use technology, don't sell printers or many of the other products in HP's printer-and-PC-centric lineup.

Apple is just plain tiny compared to HP, and of course marches to its own technological drummer. In general I like that beat -- I'm writing this on a 17-inch iMac. However, I've had big problems with Apple's iPhoto software. When I upgraded to the most recent version it hid all my photo albums and I still haven't been able to retrieve them properly. It just shows how hard integration can be. And listen to Fiorina on Sony: "It's a great company, but they lack imaging expertise, software expertise, networking expertise, and computing expertise. And those are big things that count."

HP doesn't get the credit it deserves for being the largest "consumer digital product company" in the world, as Fiorina calls it. Nobody touches HP in overall consumer computing-related revenues -- not Sony, not Dell.

Fine line

Vyomesh Joshi, or VJ as he's known, runs HP's imaging and printing group, and is the brains behind much of yesterday's fireworks. He bragged that after last year's "Big Bang," when he first made his impressive managerial presence felt with a complete makeover of consumer printers, HP boosted its revenues 22% even as the overall market declined 20%.

In some ways HP is Bill Gates' dreams come true -- a company devoting huge energy and money to integrating consumer experiences based on industry-standard Windows computers. But my friend Aaron Goldberg, a longtime PC industry expert and consultant at Ziff-Davis, says HP is walking a fine line as it seeks to integrate more and more different kinds of consumer devices around the Windows standard. "You don't want to be called incompatible," he said. "But on the other hand if you rely on the industry standards alone it won't be very compelling from an ease-of-use perspective, because the standards don't support enough integration to take away the customer's pain." He thinks HP will have to eventually move to systems that don't work well -- or at all -- with computers from Dell or Gateway. That could look more and more like the Apple model writ large.

I wrote an unflattering column in May entitled, "What is HP Today?" A big part of my point was that Dell and IBM both have clearer corporate identities. I think I overstated the case. In a subsequent conversation, Jeff Clarke, who runs HP operations, argued that Dell has only succeeded in a big way with products that require unique customer configurations, like PCs. Dell has targeted printers, in partnership with Lexmark, but Clarke says printers don't require configuration and thus aren't likely to be a big success for Dell. (And he says Dell's printer business has had no discernible impact on HP's market.) Carly elaborated further in my conversation with her yesterday: "Dell's a distribution company--a great distribution company, but that's what they are. The only way they can get the growth they need is to move as many things through that distribution chain as they can. But because they're not a technology company and they can't innovate, all they can do is follow."

The battle for PC leadership continues to seesaw between Dell and HP, but HP's global presence, its increasingly-wide range of consumer products, and its growing ability to innovate and integrate, suggest that that battle could be long, interesting, and hard-fought.

LOAD-DATE: September 26, 2003

Exhibit 38

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Exhibit 39

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Exhibit 40

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Exhibit 41

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Exhibit 42

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Exhibit 49

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